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Optimum Anthropometric Criteria for Ideal Body Composition Related Fitness

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معايير القياسات البشرية المُثلى لتركيب الجسم المثالي المتعلق باللياقة

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الخلاصة: الهدف: هناك ثلاثة أهداف لهذه الدراسة: عمل معادلات لتركيب الجسم المثالي المتعلق باللياقة لاستعماله من قبَل البالغين الراغبين بالحصول على تركيب الجسم المثالي المتعلق باللياقة، التنبؤ بمحيط العضلة الرئيسية المتناظر، وحساب النسبة المئوية المثالية لدُهْن الجسم مع الوزن المثالي للجسم بالاعتماد على منسب كتلة الجسم. **الطريقة:** تم اختيار 24 رياضيا، طول قاماتهم بين 166– 190 سم وأعمارهم بين 20 – 24 سنة، بناء على رأي لجنة استعملت المعايير المحورة للاتحاد العالمي للياقة من أجل تنافس اللياقة « فئة الجسم المفرط». اخذت القياسات البَشَرِيَّة الشائعة وتركيب الجسم للمتغيرات المستقلة : وزن الجسم، طول الطرف العلوي، طول الطرف السفلي، طول الفخذ، طول الذراع، عَرض الكتف، طول الساعد، طول الساق، محيط المعصم، وللمتغيرات المعتمدة التالية: محيط كل من الكتف والفخذ والخصر والورك والصدر والعضلة ذات الرأسين والساعد والساق والرقبة. تم قياس ثخن طية الجلد في ثلاث مناطق بفرجار هاربيندين لقياس النسبة المئوية لدهن الجسم. النتائج: تؤشر النتائج الى وجود ترابط تنبؤي بين المتغيرات المستقلة الرئيسية وقياسات محيط الجسم. كان متوسط المدى الذي استخدم لايجاد النسبة المئوية المثالية لدهن الجسم 5.6 – 6.6%. معادلة منسب كتلة الجسم التي استعملت لإيجاد وزن الجسم المثالي: H2 × 23.77 ± 2SE. استعمل التحوف المتعدد المتصاعد لاشتقاق معادلات التنبؤ. كانت أكثر المتغيرات المستقلة القابلة للتنبؤ محيط المعصم والطول.

مفتاح الكلمات: تركيب الجسم، القياسات البشرية، تمرين المقاومة.

ABSTRACT: ***Objectives:*** The three aims of this study were to establish equations for ideal body composition related fitness to be used by adults willing to gain optimum body composition related fitness; to predict the possible symmetrical major muscle circumference, and to compute the ideal body fat percentage (BFP) with ideal body weight (IBW) based on the body mass index (BMI). ***Methods:*** Twenty-four athletes were intentionally selected, with heights of 166–190 cm and aged 20–42 years, according to a judging committee that used modified International Fitness Federation criteria for the Mr. Fitness competition "super body category". Common anthropometric and body composition measurements were taken for the following independent variables: body height, upper limb length, lower limb length, thigh length, arm length, shoulder width, forearm length, shank length, and wrist girth; and for the following dependent variables: circumferences of shoulder, thigh, waist, hip, chest, biceps, forearm, shank, and neck. Skin fold thickness was measured at three sites by a Harpenden caliper to calculate BFP. ***Results:*** The findings indicate that there was a predictive correlation between major independent variables and body circumferences. The mean range used to find out the ideal BFP percentage which was 5.6–6.7 %. The BMI equation used to find the IBW was H2 × 23.77 ± 2 SE. Stepwise multiple regressions were also used to derive predictive equations. The most predictive independent variables were wrist girth and height. ***Conclusion:*** It is suggested that the above equations, the ideal BFP percentage and the IBW be used as criteria in training sessions to achieve ideal body composition related fitness.

Keywords: Body Composition; Anthropometric; Resistance training;

Advances in Knowledge

1. *This is the first study that establishes prediction equations to achieve ideal body composition related fitness.*
2. *The results of this study will help novices in developing their own resistance training programme based on the equations.*

Application to Patient Care

1. *In order to maintain good health status, patients need to follow a regular physical activity regime based on this study's equations.*
2. *Patients with posture abnormality may apply these prediction formulas to achieve body alignment and correct posture through a rehabilitation program.*

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3. *Using the equations from this study, weight reduction can be achieved through resistance training that would optimise body composition and fitness level.*
4. *The knowledge obtained from this study will encourage young people to initiate an active life style early in their lives thus preventing the occurrence of non-communicable diseases.*

Fitness club participants have different goals when they plan to workout. Some people would like to reduce weight, others to increase cardiovascular endurance, and the rest would like to develop muscle mass. For the first two groups, sufficient standards and criteria exist for the design and monitoring of an appropriate physical training programme that would lead to beneficial changes in body composition, such as reductions in body fat and increases in cardiovascular fitness. The third group, bodybuilders, compete on the size, definition, symmetry and shape of their muscular body composition. The ideal body composition related fitness represents the actual lean body mass symmetry combined with a low fat percentage that leads to a high level of health-related fitness.

However, before aiming to achieve ideal body composition related fitness, people need to follow a well-balanced diet with a regular physical activity regime early in their lives in order to maintain a good health status. Not only is regular physical activity essential for normal growth and development, but physical activity habits established early in life tend to carry over into adulthood.[1,2] Although activities that enhance cardiorespiratory fitness are generally recommended for all, research increasingly suggests that resistance training can offer unique benefits for children, adolescents, and for patients having osteoporosis, diabetics, arthritis and most non-communicable diseases, especially when appropriately prescribed and supervised.[3,4,5]

Physical fitness requirements for body builders have recently evolved away from only developing bulky muscle. Physical fitness is a term that is used interchangeably with cardiorespiratory fitness, musculoskeletal fitness and health related physical fitness. Recently, resistance training and weight training with cardio drills were developed to allow people to achieve multiple physical fitness objectives. Thus, the relationship between cardio and muscular functioning is enhanced by virtue of multiple intervention training leading to a healthier life style.[5] The American College of Sport Medicine (ACSM) recommends that young adults, who have no medical problems that may limit their acceptable level of activity, should engage in moderate intensity aerobic exercise for a minimum of 30 minutes at least 5 days a week. In addition to the recommendations for aerobic exercise, the guidelines also specify that healthy adults should engage in moderate resistance (strength) training at least twice per week and should aim to work all of the major muscle groups.[6] The available evidence suggests that muscular strength and power also prevent the risk of cardiovascular mortality, independent of cardiovascular fitness, and their development might be considered as prophylaxis for non-communicable diseases.[7,8]

In the context of promoting muscular strength and power, the International Body Fitness Federation (INBF), the non-profit amateur affiliate of the World National Bodybuilding Federation (WNBF), organises the Mr. Fit Body Contest where health fitness and body symmetry are demonstrated by contestants executing certain manoeuvres.[9] Planning, predicting, and monitoring changes in body symmetry and health fitness are critical for this calibre of bodybuilders. Anthropometrically based prediction equations designed to detect body composition changes, have not been rigorously tested in athletes. Several reports have commented on the inadequacy of various skin-fold-thickness equations to predict changes in body composition, whether modest[10,11] or large.[12,13,14] Most previous studies predicted BMI or body fat percentages from either anthropometric measures only, or with other correlation methods to body segment circumferences. To date, standard or predictive equations that would assess the relationship between body parts and the symmetrical composition of the desired ideal body composition are not available for practical application. The purpose of this study is to establish equations for ideal body composition related fitness that can be used by adults wanting to gain optimum body composition related fitness to predict the possible symmetrical major muscle circumference, and to compute the ideal body fat percentage (BFP) with ideal body weight (IBW) based on the body mass index (BMI). In this

Table 1: Descriptive statistics for the subjects' variables.

Variables	Mean	Max value	Min value	SD	M	SE	The confidence interval 95% of the sample Minimum–Maximum
Age (yr)	25.79	42	20	4.83	25.00	0.99	23.75–27.83
Height (cm)	175.02	190	166	6.32	173.25	1.29	172.35–177.69
Weight (kg)	73.50	88.7	64.8	6.21	72.85	1.27	70.87–76.12
BMI	23.78	24.8	22	0.62	23.80	0.13	23.51–24.04
Fat %	6.17	9	4	1.33	6.00	0.27	5.60–6.73
Neck circum (cm)	39.69	44	37	1.78	39.75	0.36	38.94–40.44
Chest circum (cm)	101.81	110	96	3.57	102.0	0.73	100.31–103.32
Waist circum (cm)	78.23	84	72	3.23	78.50	0.66	76.87–79.59
Hip circum (cm)	91.63	99	85	3.36	91.00	0.69	90.21–93.04
Shoulder circum (cm)	119.96	129	111	4.90	119.0	1.00	117.89–122.03
Arm circum (cm)	35.04	38.5	32	1.76	35.00	0.36	34.30–35.78
Forearm (cm)	29.77	32	28	1.29	30.00	0.26	29.22–30.32
Thigh circum (cm)	55.54	62	52	2.60	55.00	0.53	54.44–56.64
Shank circum (cm)	36.08	39	31	1.97	36.25	0.40	35.25–36.92
Arm length (cm)	33.02	38	30	1.93	33.00	0.39	32.21–33.83
Shank length (cm)	42.65	48.5	38.5	2.51	42.00	0.51	41.59–43.71
Wrist girth (cm)	17.61	19	17	0.63	17.50	0.13	17.34–17.87
Upper extremity length (cm)	80.98	89	76	2.77	81.25	0.57	79.81–82.15
Upper extremity length (cm)	94.02	103	85	4.64	95.00	0.95	92.06–95.98
Forearm length (cm)	28.17	30	25	1.38	28.50	0.28	27.58–28.75
Thigh length (cm)	43.40	48	38	2.80	44.00	0.57	42.21–44.58
Shoulder width (cm)	37.77	43	34	2.01	37.75	0.41	36.92–38.62

Legend: SE = standard error; SD = standard deviation;

context, the following questions were raised: 1) What is the ideal fat percentage for optimum body composition? 2) What is the ideal body weight for optimum body composition? 3) Which are the most predictive variables derived from this study?

Methods

Twenty-four Jordanian male athletes participated in this study. They were 20–42 years old and their height ranged between 166 and 190 cm. They were selected from a total of 84 athletes from 91 clubs by a judging committee using modified International Fitness Federation criteria for the Mr. Fit Body contest. The "Super Body" category was used as the standard for the ideal bodies for this study. They reported to have been drug-free for the previous seven years. Although, the sample size is not large, it was sufficient for the classical statistics used in this analysis as shown in the tables. The Statistical Package for the Social Sciences (SPSS) software, Version 15, was used for statistical analysis. All participants gave informed consent to participate in the study.

Common anthropometric and body composition measurements were taken for the following independent variables: body height (BH), upper limb length (ULL), lower limb length (LLL), thigh length (TL), arm length (AL), shoulder width (SW), forearm length (FL), shank length (SL), and

Table 2: Coefficient of correlation between independent and dependent variables

Variables	Shoulder width	Thigh length	Forearm length	Lower extremity Length	Upper extremity Length	Wrist girth	Shank length	Arm length	Height
Neck circum	0.20	0.30	0.27	0.518*	0.678*	0.545*	0.556*	0.468*	0.676*
Chest circum	0.32	0.457*	0.455*	0.619*	0.26	0.24	0.586*	0.26	0.570*
Waist circum	0.36	0.25	0.420*	0.690*	0.495*	0.20	0.648*	0.547*	0.722*
Hip circum	0.423*	0.23	0.32	0.715*	0.563*	0.36	0.656*	0.723*	0.774*
Shoulder circum	0.521*	0.688*	0.512*	0.697*	0.616*	0.37	0.745*	0.430*	0.781*
Arm circum	0.19	0.414*	0.39	0.33	0.33	0.26	0.39	0.13	0.39
Forearm circum	0.31	0.31	0.491*	0.520*	0.29	0.563*	0.496*	0.39	0.511*
Thigh circum	0.27	0.618*	0.27	0.500*	0.34	0.01	0.438*	0.23	0.513*
Shank circum	0.17	0.38	0.36	0.474*	0.20	0.534*	0.411*	0.38	0.437*

*Legend: * = P value at 0.05*

wrist girth (WrG); and the following dependent variables: circumferences of shoulder (Sh), thigh (T), waist (W), hip (H), chest (Ch), biceps (Bi), forearm (F), shank (S), and neck (NK). Skin fold thickness was measured at three sites with a Harpenden caliper to ascertain the subject's body fat percentage (BFP). Based on a previous pilot study and other research, all measures were reliable and valid.

Results

The descriptive anthropometric statistics mean, median, standard deviation, and minimum and maximum values for the 24 participants are presented in Table 1. The 95% confidence interval for each variable is also shown in the table. Values falling beyond this confidence interval were assumed as outliers. With respect to the first and second research questions, Table 1 illustrates 95% confidence interval for the ideal fat percentage and the ideal body weight for the optimum body composition. The formula applied to determine BMI, which uses the BW over square height in metres, can be applied inversely to predict the ideal body weight using either the mean or the values falling within the 95% confidence interval. Thus, the acceptable values used to find out the ideal BFP %, which are between 5.6 and 6.7%, can be used to determine the (IBW) which is = $H^2 \times 23.77 \pm 2SE$. Table 2 also showed that the highest significant coefficient correlation was between shoulder circumference and total body height. In addition, shoulder circumference was the dependent variable that significantly correlated with all independent variables except wrist girth. In order to determine the best prediction equation for each dependent variable, an analysis was conducted using SPSS software which uses several independent variables and one dependent variable. Stepwise multiple linear regressions were used. In addition, regression variance analysis was used to explore the explanation power for the predicted equations. Wrist girth was the independent variable most often derived as a predictor whether in isolation or combined with other independent variables. The total body height came next as shown in Table 3. The following predictive equations were derived from the statistical manipulation:

1. Neck circumference = -3.882 + 0.349 (ULL) + 0.868 (WrG)
2. Shoulder circumference = -6.221 + 0.943 (BH) + 1.031 (TL) – 0.889 (LLL)

Table 3: Summary of stepwise regression analyses for significant variables predicting selected dependent variables

Dependent Variable to Predict	Significant Prediction Variables	Coeff. of Regr.	Standard Error
Neck Circumference	Constant	-3.882	8.939
	Upper extremity length	0.349	0.106
	Wrist girth	0.868	0.468
Waist Circumference	Constant	25.772	14.233
	Height	0.459	0.087
	Wrist girth	-1.581	0.876
Hip Circumference	Constant	34.212	11.286
	Height	0.425	0.087
	Thigh length	-0.422	0.153
	Arm length	0.881	0.267
	Wrist girth	-1.528	0.716
Shank Circumference	Constant	6.666	9.943
	Wrist girth	1.671	0.564
Forearm circumference	Constant	9.406	6.379
	Wrist girth	1.157	0.362

3. Chest circumference = 57.083 + 0.476 (LLL)
4. Waist circumference = 25.772 + 0.459 (BH) – 1.581 (WrG)
5. Hip circumference = 34.212 + 0.425 (BH) – 0.442 (TL) + 0.881 (AL) - 1.528 (WrG)
6. Biceps circumference = 23.776 + 0.26 (TL)
7. Forearm circumference = 9.406 + 1.157 (WrG)
8. Thigh circumference = 30.632 + 0.574 (TL)
9. Shank circumference = 6.666 + 1.671 (WrG)

Discussion

Since the statistical analyses were run for variable values falling within the 95% confidence interval, the above equations would apply for a sample of men aged between 24 and 28 years, height between 172 and 178 cm, and body fat percentages between 5.6 and 6.7%. The ideal homogenous weight can be predicted using the formula of BMI inversely which is $H^2 \times 23.77 \pm 2SE$. This equation offers an advantage over other methods such as measures of BMI or weight, body composition, and fat distribution in assessing body composition related fitness.[13] Body weight is not a suitable measure for assessing ideal body composition related fitness because an increase in weight due to an increase in fat-free mass (FFM) can be misinterpreted as an increase in body fatness. BMI measure can not be valid for all people; hence, we should be cautious when this index is applied to the extremes of physical types such as elite athletes, the physical frail, pregnant women, and children.[15] Direct measures of percentage body fat and FFM are currently impractical for widespread use in screening for general health and fitness standards. Indirect or clinical methods usually rely on estimation of body composition from easily measured variables such as circumferences or skinfold thicknesses and use of prediction equations. Fridel *et al.* suggest that anthropometry can provide better estimates of fatness than body mass index, but it is still relatively insensitive to short-term alterations in body composition.[10]

In order to identify changes correctly and to provide positive and correct feedback, it is necessary to be able to assess progress without the use of expensive equipment or technically complex procedures. Kilani indicated that on average, fat percentages are 12 to 15% and 18 to 22% for males and females respectively. For most elite athletes, these percentages are lower and might reach 3% for bodybuilders.[15] Three percent is the lowest level of essential body fat needed for males to survive without hazardous health problems. Fat loss is well represented by a simple decrease in the abdominal girth measurement, even for the leanest men.[10] Not surprisingly, the circumference equation that includes the wrist girth and height length instead of arm and thigh lengths proved to be the most reliable to follow as shown in Table 2. Using all nine equations before enrolling into an exercise programme will lead to an optimisation of the symmetry of body segment circumferences and an ideal body weight and body fat percentage related health status.

In addition, the above equations can also be used for non-athletes, including patients, when they want to exercise in a scientific manner. In general, if patients have posture abnormalities, they may

apply these formulae to achieve body alignment and correct posture. If obesity is the major health problem, weight reduction can be achieved through resistance training that would optimise body composition and fitness level.[16] The use of the previous equations can also be prescribed to patients in rehabilitation programmes. Finally, young people need to work out based on these equations to achieve fitness and to prevent non-communicable diseases since the effective application of the equations works as prophylaxis for patients with arthritis, obesity, diabetes, and hypertension.

Conclusion

This analysis provides a thorough study of multiple anthropometric and body composition measures and their association with ideal body shape related fitness in a population highly involved in achieving muscle symmetry outcomes. The study has identified the equations for the most predictive criteria in order to achieve ideal body shape related fitness. A training programme can therefore be planned based on the initial anthropometric measurements and then predict the homogeneity of muscle bulk, definitions, and shape with fairly accurate efficiency and effectiveness. The above equations can be used to predict ideal BFP % and IBW as criteria in the training sessions to achieve ideal body composition. However, further research is still needed to confirm the validity of implementing the above predictive formulas for any active person initiating a training programme.

CONFLICT OF INTEREST

The authors report no conflict of interest.

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